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(54) **ONCE-THROUGH VERTICAL EVAPORATORS FOR WIDE RANGE OF OPERATING TEMPERATURES**

(75) Inventors: **Wesley P. Bauver, II**, Granville, MA (US); **Ian J. Perrin**, North Granby, CT (US)

(73) Assignee: **ALSTOM Technology Ltd**, Baden (CH)

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F22B 29/06 (2006.01)
F22B 35/16 (2006.01)
F22D 5/34 (2006.01)

(52) **U.S. Cl.**

CPC . ***F22B 1/18*** (2013.01); ***F22B 29/06*** (2013.01); ***F22B 35/16*** (2013.01); ***F22D 5/34*** (2013.01)

(58) **Field of Classification Search**

USPC .... 122/7 R, 253, 406.1
See application file for complete search history.

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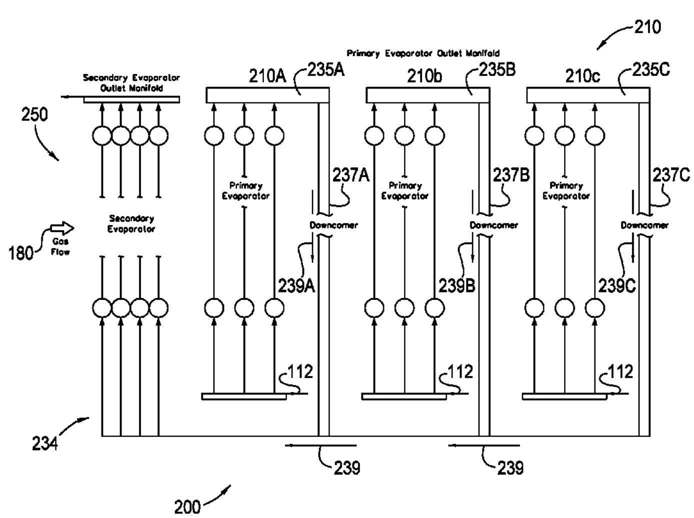
Primary Examiner — Alissa Tompkins
Assistant Examiner — John Bargero
(74) *Attorney, Agent, or Firm* — Robert D. Crawford

(57) **ABSTRACT**

An evaporator for steam generation is presented. The evaporator includes a plurality of primary evaporator stages and a secondary evaporator stage. Each primary stage includes one or more primary arrays of heat transfer tubes, an outlet manifold coupled to the arrays, and a downcomer coupled to the manifold. Each of the primary arrays has an inlet for receiving a fluid and is arranged transverse to a flow of gas through the evaporator. The gas heats the fluid flowing through the arrays to form a two phase flow. The outlet manifold receives the two phase flow from the arrays and the downcomer distributes the flow as a component of a primary stage flow. One or more of the plurality of primary evaporator stages selectively form the primary stage flow from respective components of the two phase flow, and provide the primary stage flow to inlets of the secondary evaporator stage.

22 Claims, 4 Drawing Sheets



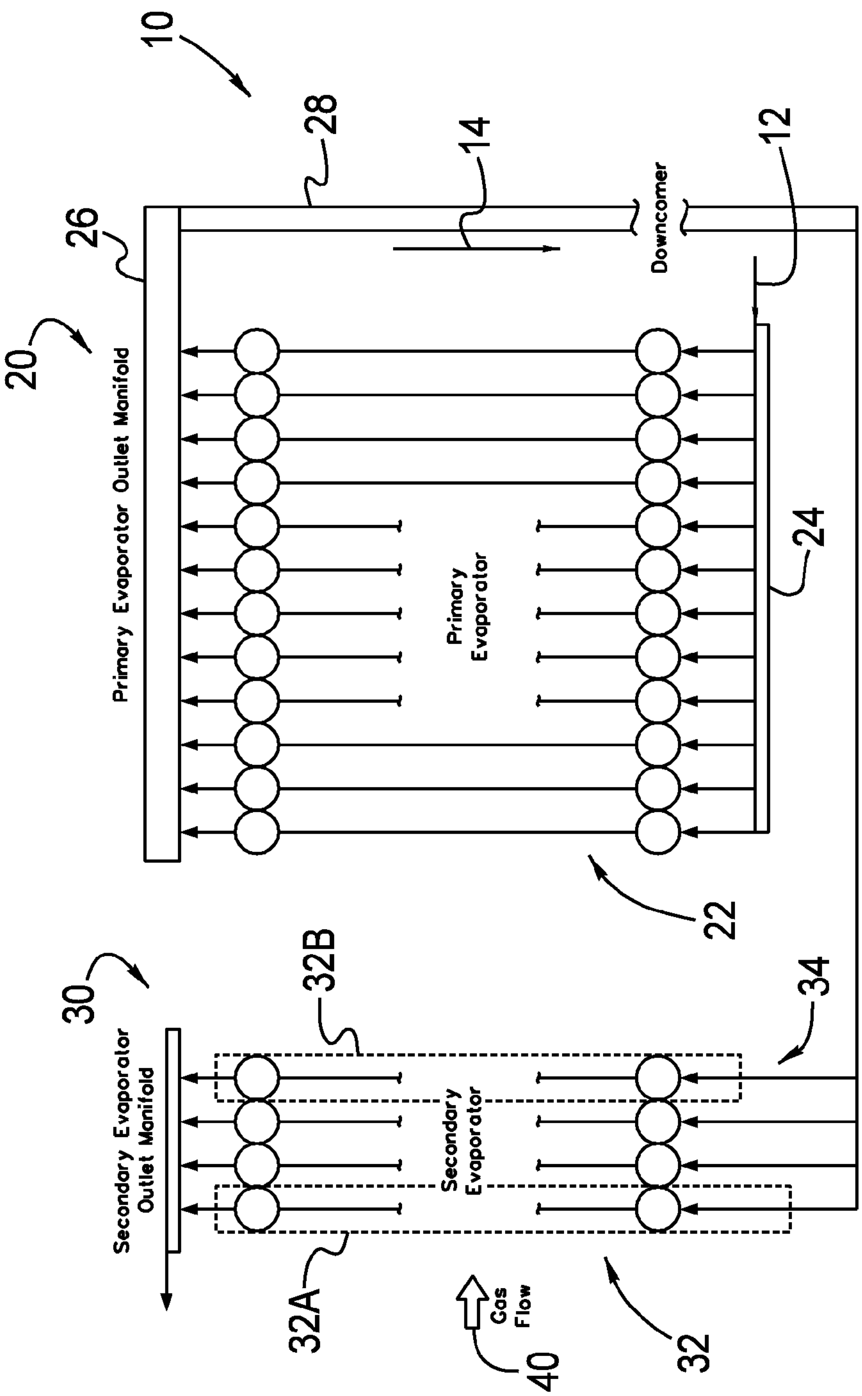


FIG. 1
(Prior Art)

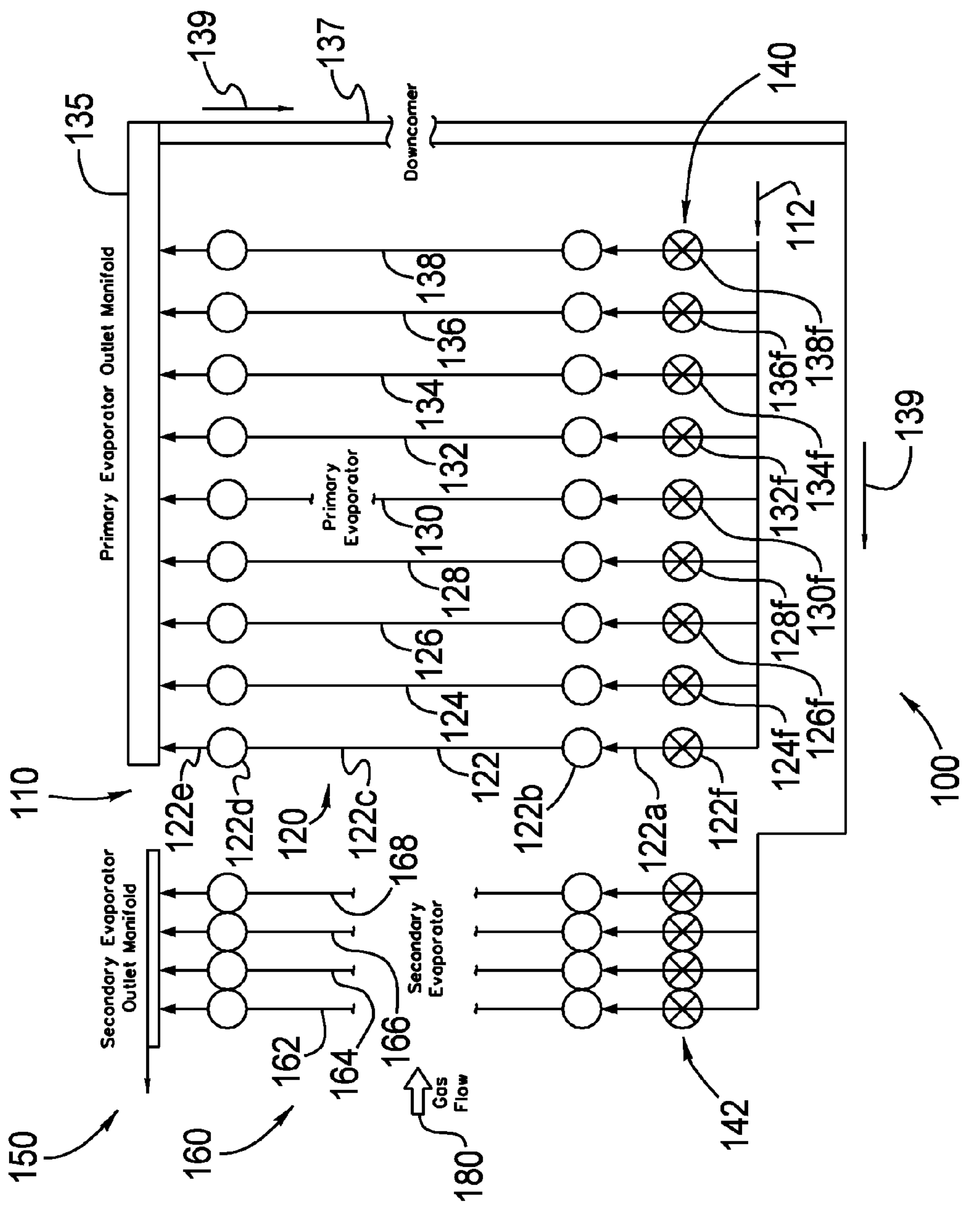

Primary Evaporator Outlet Manifold
Downcomer
Primary Evaporator
Secondary Evaporator Outlet Manifold
Secondary Evaporator
Gas Flow
100
110
112
120
122
122a
122b
122c
122d
122e
122f
124
124f
126
126f
128
128f
130
130f
132
132f
134
134f
135
136
136f
137
138
138f
139
140
142
150
160
162
164
166
168
180

FIG. 2

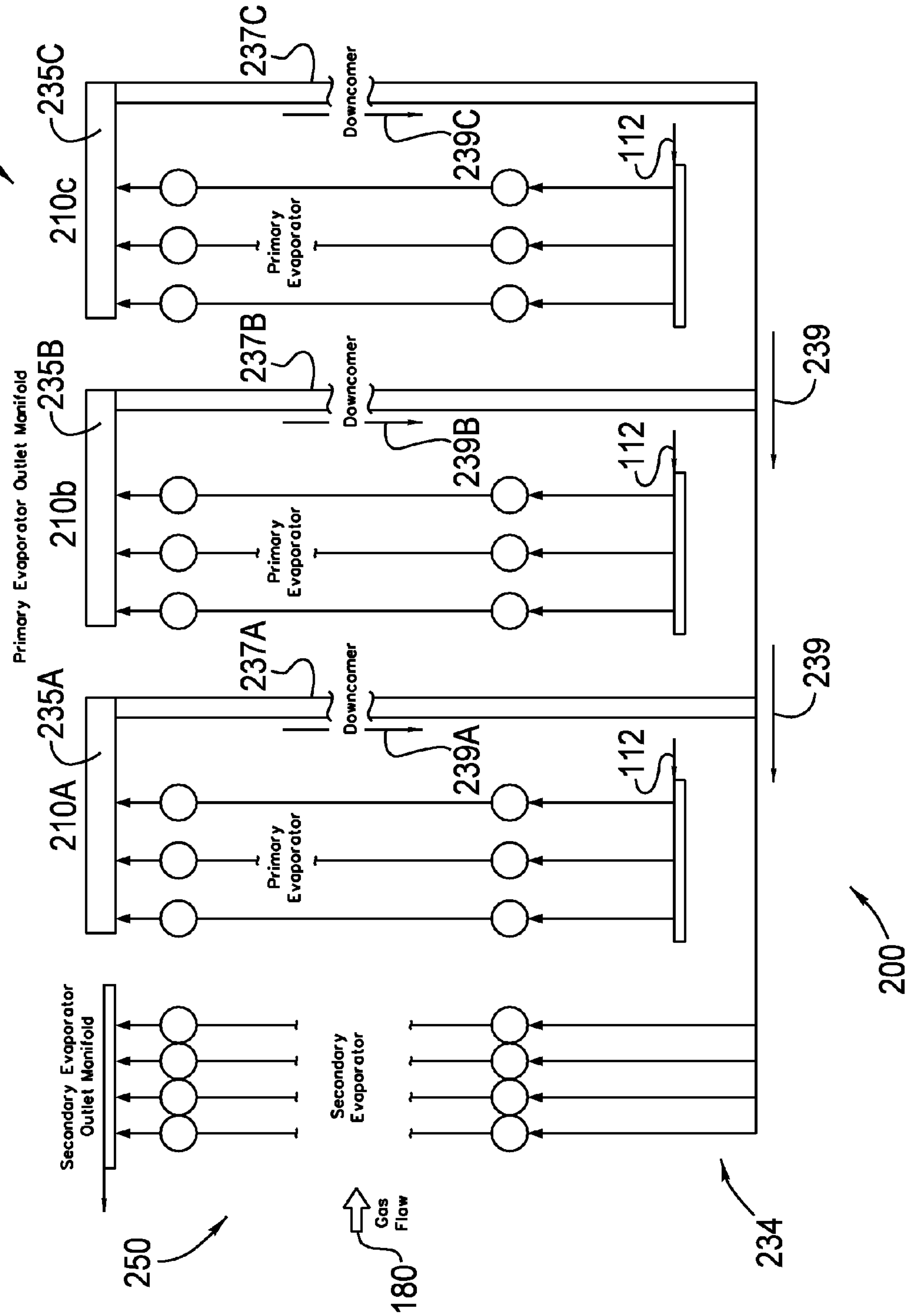

210
235C
237C
Downcomer
239C
112
210c
Primary Evaporator
237B
235B
Primary Evaporator Outlet Manifold
Downcomer
239B
239
210b
237A
235A
Downcomer
239A
210A
Secondary Evaporator Outlet Manifold
Secondary Evaporator
Gas Flow
250
180
234
200

FIG. 3

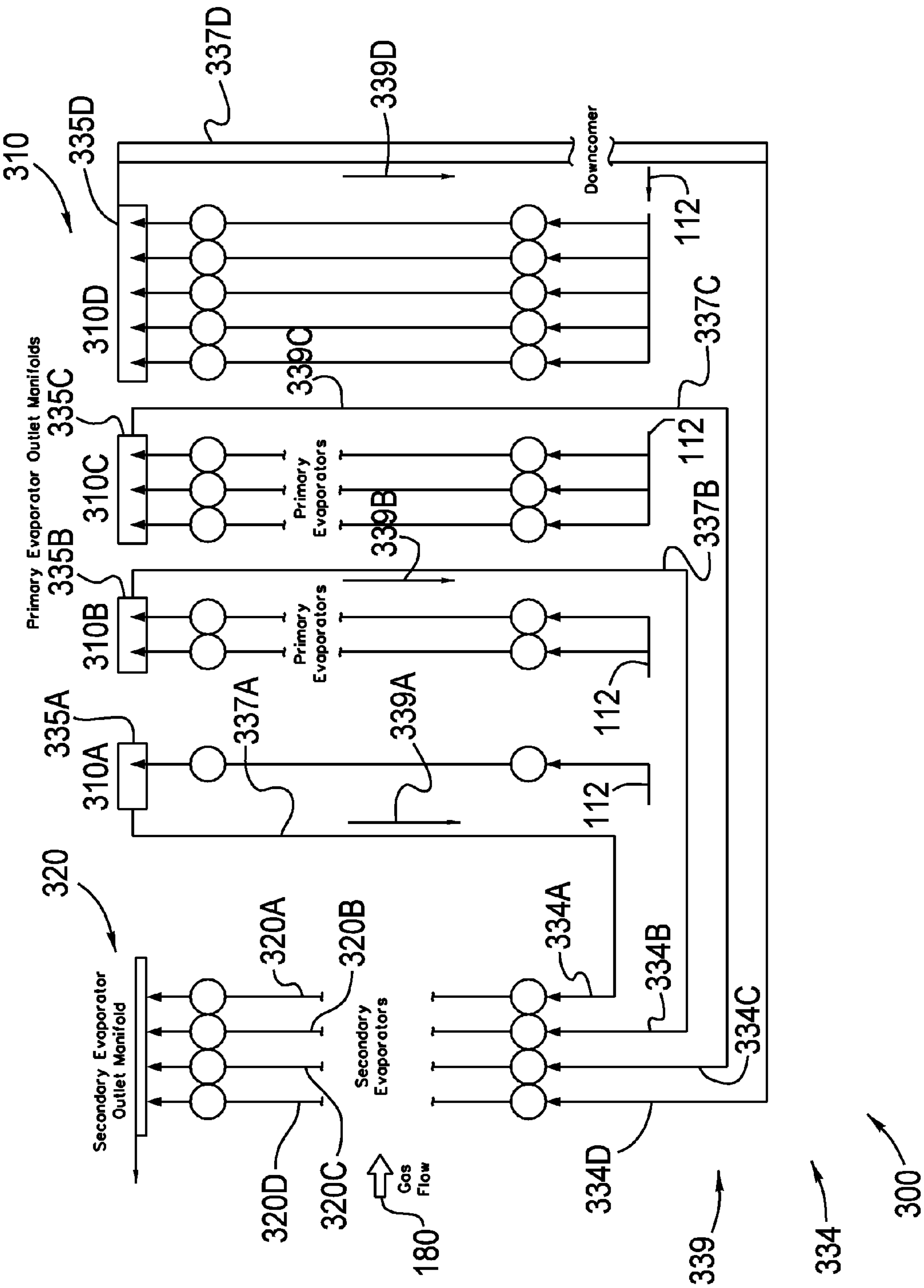

310
335D
337D
339D
Downcomer
112
310D
Primary Evaporator Outlet Manifolds
335C
339C
337C
310C
Primary Evaporators
112
335B
310B
339B
337B
Primary Evaporators
112
335A
310A
337A
339A
112
320
320A
320B
Secondary Evaporator Outlet Manifold
Secondary Evaporators
334A
334B
334C
334D
320D
320C
Gas Flow
180
339
334
300

FIG. 4

ONCE-THROUGH VERTICAL EVAPORATORS FOR WIDE RANGE OF OPERATING TEMPERATURES

TECHNICAL FIELD

The present disclosure relates generally to once-through evaporators and, more specifically, to once-through evaporators that minimize flow instabilities for improved reliability and performance over a wide range of operating conditions.

BACKGROUND OF THE INVENTION

Generally speaking, once-through evaporator technology may be employed within generating systems such as, for example, steam generating systems, and include multiple heat exchange sections or stages. Typically, there are two heat exchange stages. In a first or primary evaporator stage, a fluid such as, for example, feed water, is partially evaporated to produce a steam/water mixture. In a second or secondary evaporator stage the fluid is further evaporated to dryness and the steam is superheated.

As shown in FIG. **1**, a conventional once-through evaporator **10** includes heat exchange stages, e.g., primary evaporator stage **20** and secondary evaporator stage **30** that each includes a parallel array of heat transfer tubes **22** and **32**, respectively. Mass flow rate within internal portions of the tubes **22** and **32** is controlled by buoyancy forces, for example, density differences induced by heat transfer to the fluid in the tubes such that the mass flow rate is proportional to the heat input to each individual tube within the arrays of tubes **22** and **32**. One type of evaporator uses vertical tubes arranged as a sequential array of individual tube bundles. Each tube bundle (e.g., a bundle **32**A of FIG. **1**), also referred to as a harp, has one or more rows of tubes that are transverse to a flow of a hot gas **40** (e.g., a flue gas). The individual harps **32**A are arranged in the direction of gas flow so that a downstream harp (e.g., a harp **32**B) absorbs heat from the gas of a lower temperature than the upstream harp **32**A. In this way, the heat absorbed by each harp in the direction of gas flow is less than the heat absorbed by the upstream harp.

As shown in FIG. **1**, the primary evaporator stage **20** (e.g., the array of tubes **22**) receives a fluid **12** (e.g., feed water) at an inlet manifold **24** and distributes a water/steam mixture **14** (e.g., a two-phase flow) from an outlet manifold **26** of the primary evaporator stage **22** into the secondary evaporator stage **30** (e.g., the array of tubes **32**) where dry-out and superheating takes place. The secondary evaporator stage **30** includes a plurality of inlets **34**, one or more inlets at each of the harp bundles of the secondary stage **30**. As such, the two-phase flow **14** passes through each branch of the secondary stage **30**, e.g., harps **32**A and **32**B, and the harps disposed therebetween.

Operating experience has shown that flow instabilities can develop in the primary evaporator stage **20**, which can lead to fluctuating temperatures within the tubes **32** of the secondary evaporator stage **30**. The fluctuating temperatures can lead to fluctuating thermal stress within the tubes and may result in various tube failures such as, for example, tube cracks. Techniques are known to minimize flow instabilities in the primary evaporator stage. For example, it is known that by increasing the pressure drop across individual harps within the array of tubes **22**, flow rates that would normally be controlled by buoyancy can be overcome. Techniques employed include installing an orifice in the inlet of each row of the tubes **22** or reducing an inside diameter of the inlets or tubes themselves.

Calculations show that different distributions of resistance for each row of tubes in the primary evaporator maintain stability over a range of operating conditions. However, this limits the stable operational range for a given primary evaporator configuration. For example, a set of orifices designed to provide stability at full load operation may not be effective in partial load operation. As such, instabilities may occur during operation at partial loads. Moreover, an additional problem that can limit the operation of the evaporator at low load is that at low mass flow rates the velocities in the downcomer, e.g., conduit **28** of FIG. **1**, that passes the two-phase flow **14** from the outlet manifold **26** of the primary evaporator stage **20** into the secondary evaporator stage **30**, may become too low to carry steam bubbles down and away from the outlet manifold **26**. As a result there can be a build-up of steam either or both in a top portion of the downcomer (conduit **28**) and/or at the primary evaporator outlet manifold **26**. A build-up of steam may induce additional flow instabilities.

Accordingly, there is a need to develop systems and methods for mitigating flow instabilities and fluctuating thermal stress that can result therefrom to minimize tube failure.

SUMMARY

According to aspects illustrated herein, there is provided an evaporator for steam generation. The evaporator includes a plurality of primary evaporator stages and a secondary evaporator stage. Each of the plurality of primary evaporator stages includes one or more primary arrays of heat transfer tubes, an outlet manifold coupled to the one or more primary arrays of tubes, and a downcomer coupled to the outlet manifold. Each of the primary arrays of tubes has an inlet for receiving a fluid and is arranged transverse to a flow of gas through the evaporator. The flow of gas heats the fluid flowing through the primary arrays of tubes to form a two phase flow. The outlet manifold receives the two phase flow from the primary arrays of tubes. The downcomer distributes the two phase flow from the outlet manifold as a component of a primary stage flow. One or more of the plurality of primary evaporator stages selectively form the primary stage flow from respective components of the two-phase flow, and provide the primary stage flow to the secondary evaporator stage. The secondary evaporator stage includes one or more secondary arrays of heat transfer tubes. Each of the secondary arrays of tubes is coupled to an inlet and is arranged transverse to the flow of gas through the evaporator.

In one embodiment, the inlet of each of the secondary arrays of tubes is comprised of a common inlet for all the secondary arrays of tubes such that the primary stage flow is received in parallel across all of the secondary arrays of tubes. In another embodiment, the inlet of each of the secondary arrays of tubes is comprised of an individual inlet for each of the secondary arrays of tubes. The individual inlet is coupled to the downcomer of a respective one of the plurality of primary evaporator stages such that the individual inlet receives the component of the primary stage flow from the downcomer.

In yet another embodiment, the evaporator further includes at least one valve coupled to the inlet of each of the primary arrays of tubes. The valve is selectively controlled to close off the selected primary array of tubes. For example, the valve regulates at least one of pressure drop and mass flow rate between one or more of the primary arrays of tubes to minimizing steam build up in the primary evaporator stage.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the Figures, which are exemplary embodiments, and wherein the like elements are numbered alike:

FIG. **1** is a simplified block diagram of a conventional two stage once-through evaporator;

FIG. **2** is a simplified block diagram a once-through evaporator configured and operating in accordance with one embodiment;

FIG. **3** is a simplified block diagram a once-through evaporator configured and operating in accordance with another embodiment; and

FIG. **4** is a simplified block diagram a once-through evaporator configured and operating in accordance with another embodiment.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Disclosed herein are systems and methods for control and optimization of at least one of pressure, mass flow rate and differential temperature within evaporators such as, for example, once-through evaporators employed within, for example, generation plants. The control and optimization system selectively adjusts pressure, mass flow and/or temperature within tubes of the evaporator flow to eliminate and/or substantially minimize instabilities and fluctuating thermal stress to improve and/or prolong, for example, operational life of the tubes.

In one embodiment, illustrated in FIG. **2**, a once-through evaporator **100** includes two heat exchange stages, a primary evaporator stage **110** and a secondary evaporator stage **150**. Each stage includes a plurality of parallel arrays of heat transfer tubes, shown generally at **120** and **160**. Each of the arrays **120** and **160** includes one or more harps. For example, the primary evaporator stage **110** includes the array **120** having harps **122**, **124**, **126**, **128**, **130**, **132**, **134**, **136** and **138**. The secondary evaporator stage **150** includes the array **160** having harps **162**, **164**, **166**, and **168**. Each of the harps includes one or more rows of tubes that are transverse to a flow of gas **180** (e.g., a hot gas, a flue gas, and the like) through the evaporator **100**. For example, the harp **122** includes one or more lower tubes **122***a*, one or more lower headers **122***b*, one or more intermediate tubes **122***c*, one or more upper headers **122***d* and one or more upper tubes **122***e* in fluid communication and extending vertically upward from the lower tube **122***a* through to the upper tube **122***e*. In one embodiment, each of the harps **124**, **126**, **128**, **130**, **132**, **134**, **136**, **138**, **162**, **164**, **166** and **168** are configured similarly to harp **122**. It should be appreciated that, for clarity and not as a limitation of the present disclosure, FIGS. **2**-**4** illustrate each of the arrays of harps **120**, **160**, **210**, **250**, **310**, and **320** as including one lower tube, one lower header, one intermediate tube, one upper header and one upper tube.

In the evaporator **100**, the primary evaporator stage **110** receives a fluid **112** (e.g., feed water). The fluid **112** at least partial evaporates in the primary evaporator stage **110** and is distributed as a two-phase flow **139** (e.g., a water/steam mixture) from an outlet manifold **135** of the primary evaporator stage **110** into the secondary evaporator stage **150** via a conduit **137** (e.g. a downcomer). In the secondary evaporator stage **150** dry-out and superheating of the flow **139** takes place. As described above with reference to FIG. **1**, mass flow rate within internal portions of the tubes of an evaporator is typically controlled by buoyancy forces, for example, density differences induced by heat transfer to the fluid in the tubes. In FIG. **2**, one or more valves **140** are used to provide variable pressure drops for one or more of the arrays of tubes **120** in the primary evaporator stage **110**. For example, valves **122***f*, **124***f*, **126***f*, **128***f*, **130***f*, **132***f*, **134***f*, **136***f* and **138***f* are respectively coupled to the lower tubes of harps **122**, **124**, **126**, **128**, **130**, **132**, **134**, **136** and **138**. The valves **140** are selectively controlled to regulate at least one of pressure and/or mass flow within the arrays of tubes **120** in the primary evaporator stage **110** individually, in total, or in any combination thereof. For example, at a low flow rate, the valves **140** are controlled to completely stop a flow of liquid (e.g., feed water) in one or more of the arrays **120** of the primary evaporator stage **110**. The stoppage of flow in selective arrays **120** (e.g., one or more of the harps **122**, **124**, **126**, **128**, **130**, **132**, **134**, **136** and **138**) permits, for example, an increase of flow through remaining ones of the arrays **120**. This ability to balance the flow of liquid through the primary evaporator stage **110** prevents or, at least substantially minimizes, steaming or too high an exit liquid quality, in the primary evaporator stage **110**. In one embodiment, harps at a rear portion (e.g., the rear being a direction away from the direction of the gas flow **180**) of the primary evaporator **110** (e.g., starting at harp **138** and proceeding to harp **136**, next to harp **134**, then to harp **132**, etc.) receive the gas flow **180** at a lower temperature. One or more of the harps at the rear portion may be selectively operated without fluid. Additionally valves **142** are selectively controlled to regulate and balance flow (e.g., portions of the two-phase flow **139**) into the harps **162**, **164**, **166**, and **168** of the secondary evaporator stage **150** to maintain a more uniform exit quality and/or temperature to control tube-to-tube temperature differences.

Moreover, it should be appreciated that the valves **122***f*, **124***f*, **126***f*, **128***f*, **130***f*, **132***f*, **134***f*, **136***f* and **138***f* of the primary evaporator stage **110** and/or valves **142** of the secondary evaporator stage **150** may selectively control a flow rate into each harp such that a flow leaving one or more of the harps (e.g., via the upper tube such as the upper tube **122***e* of harp **122**) is heated to a required or predetermined value of temperature or quality. At least one perceived advantage of this selective control of the flow rate through a harp is an elimination, or substantial minimization, in instability of the flow at all operating conditions.

In another embodiment, illustrated in FIG. **3**, a once-through evaporator **200** includes a plurality of primary evaporator stages **210** (e.g., three stages **210**A, **210**B and **210**C are shown for illustration) and a secondary evaporator stage **250**. The plurality of primary evaporator stages **210** receives the fluid **112**. The fluid **112** at least partially evaporates in one or more of the primary evaporator stages **210** and is distributed as a two phase flow **239** (e.g., a flow of water and steam) from the primary evaporator stages **210**. For example, the plurality of primary evaporator stages **210** selectively cooperate to provide the two phase flow **239** to the secondary evaporator state **250**. As shown in FIG. **3**, a first primary evaporator stage **210**A provides a first component **239**A of the flow **239** from an outlet manifold **235**A through a first conduit or downcomer **237**A, a second primary evaporator stage **210**B provides a second component **239**B of the flow **239** from an outlet manifold **235**B through a second conduit or downcomer **237**B, and a third primary evaporator stage **210**C provides a third component **239**C of the flow **239** from an outlet manifold **235**C through a third conduit or downcomer **237**C. One or more of the components **239**A, **239**B and **239**C of the two phase flow may be combined to form the two phase flow **239** from the plurality of primary evaporator stages **210** that is provided to a common inlet **234** for the secondary evaporator stage **250**.

It should be appreciated that the use of the plurality of primary evaporator stages **210** provides that, for example, at low load conditions (e.g., about forty percent (40%) of full load of the evaporator **200**) one or more of the primary evaporator stages **210**A, **210**B and **210**C can be closed off. By closing off one or more of the primary evaporator stages **210**A, **210**B and **210**C, a velocity in remaining downcomers, e.g., one or more of the downcomers **237**A, **237**B and **237**C, can be maintained at an appropriate or desirable magnitude to eliminate, or at least substantially minimize, problems of steam bubble rise and buildup. In one embodiment, the evaporator **200** may include valves (such as valves **140** and **142** of FIG. **2**) employed to control a flow to individual harps of the plurality of primary evaporator stages **210**A, **210**B and **210**C as well as harps of the secondary evaporator stage **250**. The valves may be used to close off one or more selected primary evaporator stages. In one embodiment, an evaporator stages may be taken out of service starting, for example, at a "back" of the primary evaporator stage, where a front and back of the stages **210** are defined by a direction of gas flow through the evaporator **200**. Stages may be taken out of service at a condition where instability develops as determined by, for example, fluctuating temperatures at the outlet of the secondary evaporator **250**. Such instability may be due to, for example, steam buildup in the primary evaporator outlet manifold **235**A-**235**C and/or relatively low velocities of flow through the downcomers **237**A-**237**C.

In another embodiment, illustrated in FIG. **4**, a once-through evaporator **300** includes a plurality of primary evaporator stages **310** (e.g., four primary evaporator stages **310**A, **310**B, **310**C and **310**D are shown for illustration) and a secondary evaporator stage **320**. Each primary evaporator stage **310** receives the fluid **112**. The fluid **112** at least partial evaporates in one or more of the primary evaporator stages **310** and is distributed as a two phase flow **339** (e.g., a flow of water and steam) to the secondary evaporator stage **320**. For example, the plurality of primary evaporator stages **310**A, **310**B, **310**C and **310**D cooperate to supply components **339**A-**339**D of the flow **339** to individual inlets **334**A-**334**D of the secondary evaporator stage **320** (e.g., inlets **334**A-**334**D of a plurality of secondary arrays of heat transfer tubes **320**A, **320**B, **320**C and **320**D) from a respective outlet manifold **335**A-**335**D through a respective conduit or downcomer **337**A-**337**D. As shown in FIG. **4**, a first primary evaporator stage **310**A provides a first component **339**A of the flow **339** from an outlet manifold **335**A through a first conduit or downcomer **337**A to inlet **334**A of a fourth of the secondary array of tubes **320**A, a second primary evaporator stage **310**B provides a second component **339**B of the flow **339** from an outlet manifold **335**B through a second conduit or downcomer **337**B to inlet **334**B of a third of the secondary arrays of tubes **320**B, a third primary evaporator stage **310**C provides a third component **339**C of the flow **339** from an outlet manifold **335**C through a third conduit or downcomer **337**C to inlet **334**C of a second of the secondary arrays of tubes **320**C, and a fourth primary evaporator stage **310**D provides a fourth component **339**D of the flow **339** from an outlet manifold **335**D through a fourth conduit or downcomer **337**D to inlet **334**D of a first of the secondary arrays of tubes **320**D. It should be appreciated that the above-described primary-to-secondary evaporator stage arrangement provides for more uniform outlet temperatures out of the secondary evaporator **320** as the flow from the rear most primary evaporator (e.g., the fourth primary evaporator stage **310**D) that is of, for example, a lowest quality, goes to a front most array of the secondary evaporator stage (e.g., the first of the secondary arrays of tubes **320**D) where the gas temperature is the highest. In a similar manner, as the quality increases from the primary evaporator stages progressively forward in the direction of gas flow the component of the two-phase flow **339** from these stages goes to respective ones of the secondary arrays of tubes **320**A-**320**C with progressively lower gas temperatures.

It should be appreciated that the use of the plurality of primary evaporator stages **310** provides that, for example, at low load conditions one or more of the primary evaporator stages **310**A, **310**B, **310**C and **310**D can be closed off to regulate a velocity in the remaining downcomers, e.g., one or more of the downcomers **337**A-**337**D. In one embodiment, the evaporator **300** may include valves (such as valves **140** and **142** of FIG. **2**) employed to control a flow to individual harps of the plurality of primary evaporator stages **310** as well as harps of the secondary evaporator stage **320**.

As should be appreciated, the numbers of tubes (e.g., harps) in each evaporator stage (e.g., the primary evaporator stages **210**, **310** and the secondary evaporator stages **250**, **320**) is selected to avoid steaming in the primary evaporator stages, achieve an optimal or preferred superheating in each of the secondary evaporator stage, and achieve an optimal or preferred mass flow to a corresponding secondary evaporator stage to maximize heat transfer.

While the present disclosure has been described with reference to various exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. An evaporator for steam generation, the evaporator comprising:

a first primary evaporator stage including:

a first inlet manifold for receiving a fluid;

a first primary array having at least one harp, each harp including a plurality of heat transfer tubes, each harp of the first primary array in fluid communication with the first inlet manifold for receiving the fluid and arranged transverse to a flow of gas through the evaporator, the flow of gas heating the fluid flowing through the first primary array to form a two phase flow exiting the harps of the first primary array;

a first outlet manifold coupled to the harps of the first primary array to receive the two phase fluid therefrom; and

a first downcomer fluidly coupled to the first outlet manifold to pass the two phase flow therethrough;

a second primary evaporator stage including:

a second inlet manifold for receiving the fluid;

a second primary array having at least one harp, each harp including a plurality of heat transfer tubes, each harp of the second primary array in fluid communication with the second inlet manifold for receiving the fluid and arranged transverse to the flow of gas through the evaporator, the flow of gas heating the fluid flowing through the second primary array to form a two phase flow exiting the harps of the second primary array;

a second outlet manifold coupled to the harps of the second primary array to receive the two phase flow therefrom; and a second downcomer fluidly coupled to the second outlet manifold to pass the two phase fluid therethrough; and

a secondary evaporator stage including:

a common inlet in fluid communication with the first downcomer and the second downcomer to receive the two-phase fluid from the first downcomer and the second downcomer; and

a secondary array having at least one harp, each harp including a plurality of heat transfer tubes, wherein each harp of the secondary array is arranged transverse to the flow of gas through the evaporator, and wherein the common inlet is in fluid communication with each of the harps of the secondary array to provide the two phase fluid from the first downcomer and the second downcomer.

2. The evaporator of claim **1**, further including:

a valve coupled to an inlet of each tube of the first and second primary arrays, the valves being selectively controlled to close off a selected first and/or second primary array.

3. The evaporator of claim **1**, further including:

a valve coupled to an inlet of each of the tubes of the secondary array, the valve being selectively controlled to close off a selected harps of the secondary array.

4. The evaporator of claim **1**, wherein the first primary array and the second primary array have a different number of harps.

5. The evaporator of claim **1**, wherein the first primary array is disposed upstream of the second primary array in relation to the direction of the flow of gas passing through the evaporator, and wherein first primary array has fewer harps than the second primary array.

6. The evaporator of claim **1**, wherein the fluid is feedwater.

7. The evaporator of claim **1**, further comprising a third outlet manifold for receiving the fluid passing through each of the harps of the secondary array.

8. The evaporator of claim **1**, wherein the fluid is provided to the bottom of the first primary array and second primary array.

9. The evaporator of claim **1**, wherein the secondary array is disposed upstream of the first and second primary array in relation to the direction of the flow of gas passing through the evaporator.

10. The evaporator of claim **1**, wherein heat transfer tubes of the first primary array, the second primary array and the secondary array are vertical tubes.

11. The evaporator of claim **1**, wherein the two-phase fluid from the first downcomer and the second downcomer to the common inlet is unseparated.

12. The evaporator of claim **1**, wherein substantially all the two-phase fluid from the first downcomer and the second downcomer is provided to the common inlet.

13. An evaporator for steam generation, the evaporator comprising:

a first primary evaporator stage including:

a first inlet manifold for receiving a fluid;

a first primary array having at least one harp, each harp including a plurality of heat transfer tubes, each harp of the first primary array in fluid communication with the first inlet manifold for receiving the fluid and arranged transverse to a flow of gas through the evaporator, the flow of gas heating the fluid flowing through the first primary array to form a two phase flow exiting the harps of the first primary array;

a first outlet manifold coupled to the harps of the first primary array to receive the two phase flow therefrom; and

a first downcomer fluidly coupled to the first outlet manifold to pass the two phase flow therethrough;

a second primary evaporator stage including:

a second inlet manifold for receiving the fluid;

a second primary array having at least one harp, each harp including a plurality of heat transfer tubes, each harp of the second primary array in fluid communication with the second inlet manifold for receiving the fluid and arranged transverse to the flow of gas through the evaporator, the flow of gas heating the fluid flowing through the second primary array to form a two phase flow exiting the harps of the second primary array;

a second outlet manifold coupled to the harps of the second primary array to receive the two phase flow therefrom; and

a second downcomer fluidly coupled to the second outlet manifold to pass the two phase fluid therethrough; and

a secondary evaporator stage including:

a first inlet to receive the two phase flow from the first downcomer;

a second inlet to receive the two phase flow from the second downcomer;

a secondary array having a plurality of harps, each harp including a plurality of heat transfer tubes arranged transverse to the flow of gas through the evaporator, wherein at least one of the harps of the secondary array is fluidly coupled to the first inlet to receive the two-phase flow passing through the first downcomer and at least one of the other harps of the secondary array is fluidly coupled to the second inlet to receive the two phase flow passing through the second downcomer.

14. The evaporator of claim **13**, further including:

a valve coupled to an inlet of each of tubes of the first and second primary arrays, the valves being selectively controlled to close off a selected first and/or second primary array.

15. The evaporator of claim **14**, further including:

a valve coupled to an inlet of each of the tubes of the secondary array, the valve being selectively controlled to close off a selected harps of the secondary array.

16. The evaporator of claim **13**, wherein the first primary array and the second primary array have a different number of harps.

17. The evaporator of claim **13**, wherein the first primary array is disposed upstream of the second primary array in relation to the direction of the flow of gas passing through the evaporator, and wherein first primary array has fewer harps than the second primary array.

18. The evaporator of claim **13**, wherein the fluid is feedwater.

19. The evaporator of claim **13**, further comprising a third outlet manifold for receiving the fluid passing through each of the harps of the secondary array.

20. The evaporator of claim **13**, wherein the fluid is provided to the bottom of the first primary array and second primary array.

21. The evaporator of claim **13**, wherein the secondary array is disposed upstream of the first and second primary array in relation to the direction of the flow of gas passing through the evaporator.

22. The evaporator of claim **13**, wherein heat transfer tubes of the first primary array, the second primary array and the secondary array are vertical tubes.

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